Atmospheric Dynamics I

- h. Evaluate vertical motion methods from Quasi-Geostrophic Theory and Isentropic Analysis.

Vertical motions:

- Evaluation of synoptic scale vertical motion fields are of primary importance in analyzing and forecasting synoptic scale weather.

Vertical motions

- The equation for mass continuity links divergence (convergence) of the horizontal wind to lifting (sinking)(i.e., chimney and damper effect).

Vertical motions

- The actual horizontal wind direction and speed cannot be measured with enough accuracy to allow direct calculations of the resulting vertical wind.

Vertical motions

- Alternative “indirect” vertical motion methods must be developed which may be partially or totally independent of the actual wind.
- Two of the most popular indirect methods are the Omega Equation (both classical and Trenberth) and Q vector methods, derived from Q-G wind relationships.

Vertical motions

- Another method, now available in real time because of advanced computer workstation technology in forecast offices, depicts wind flow, moisture, and isobar surfaces on an isentropic (i.e., potential temperature) surface.

Quasi-Geostrophic Theory and Vertical Motion

- Main assumptions of Q-G Theory:
  - The atmosphere is in hydrostatic balance (i.e., the atmosphere is thermodynamically stable)
    - Hydrostatic balance is destroyed near thunderstorms where the atmosphere is unstable.

Quasi-Geostrophic Theory and Vertical Motion

- The wind is quasi-geostrophic (i.e., flows essentially parallel to the height contours.
  - Advantages:
    - Height contour patterns may replace the actual wind flow.
    - No actual wind observations are required.
- No small scale weather features are required.
- Only a single analysis of vorticity, isobaric heights, and temperatures are required.

Quasi-Geostrophic Theory and Vertical Motion

- Divergence/convergence is small.
  - Regions of inactive weather and small vertical motions.

Quasi-Geostrophic Theory and Vertical Motion

- Main limitations of Q-G theory:
  - Provides only a first inference of where and why vertical motion may be occurring in the atmosphere.
  - Should not be applied in the tropics where synoptic scale flow is more ageostrophic in nature.
  - Should be used with great caution in active weather regions where divergence is large and non-hydrostatic conditions may exist.

Quasi-Geostrophic Theory and Vertical Motion

- Vertical motion produced by topography (i.e., friction), latent heating (i.e., convection), evaporative cooling, radiational heating and cooling, and small scale processes will not be represented by Q-G theory and the Omega Equation.

Classical Omega Equation

- Regions of synoptic scale vertical motion can be estimated by the Omega Equation, represented below by a relationship between vorticity advection and temperature advection

$$VM = \frac{\left[\Delta(\eta_g \; Advection)\right]}{\Delta z} + \left[TAdv\right]_{(lower\;troposphere)}$$

(Term 1) (Term 2) (Term 3)

Classical Omega Equation

$$VM = \frac{\left[\Delta(\eta_g Advection)\right]}{\Delta z} + \left[TAdv\right]_{(lower\ troposphere)}$$

(Term 1) (Term 2) (Term 3)

Where:

Term 1 = Vertical Motion

- Lifting occurs when Term 1 is positive
  - Indicates divergence in upper troposphere
  - Indicates convergence in lower troposphere

Classical Omega Equation

$$VM = \frac{\left[\Delta(\eta_g Advection)\right]}{\Delta z} + \left[TAdv_{(lower\ troposphere)}\right]$$

(Term 1) (Term 2) (Term 3)

Where:

Term 1 = Vertical Motion

- Sinking occurs when Term 1 is negative
  - Indicates convergence in upper troposphere
  - Indicates divergence in lower troposphere

Classical Omega Equation

$$VM = \frac{\left[\Delta(\eta_g \, Advection)\right]}{\Delta z} + \left[TAdv_{(lower\,troposphere)}\right]$$

(Term 1) (Term 2) (Term 3)

Where:

Term 2 = Change in absolute vorticity advection with change in height

- PVA increasing with height makes Term 2 positive
- NVA increasing with height makes Term 2 negative

Classical Omega Equation

$$VM = \frac{\left[\Delta(\eta_g \; Advection)\right]}{\Delta z} + \left[TAdv\right]_{(lower\;troposphere)}$$

(Term 1) (Term 2) (Term 3)

Where:

Term 3 = Temperature advection in the lower troposphere

- Warm advection makes Term 3 positive
- Cold advection makes Term 3 negative

Classical Omega Equation

- Terms 2 and 3 may have like signs
  - Both terms 2 and 3 may be positive, thus enhancing the magnitude of lifting (i.e., Term 1 is strongly positive)
  - Both Terms 2 and 3 may be negative, thus enhancing the magnitude of sinking.

Classical Omega Equation

- However, Terms 2 and 3 may have opposite signs (i.e., Term 2 may be positive and Term 3 may be negative), thus tending to offset one another and reduce the magnitude of lifting or sinking (i.e., Term 1)

Classical Omega Equation

- Term 2 may be positive and Term 3 may be negative, thus tending to offset and cancel one another and reduce the magnitude of lifting or sinking (i.e., Term 1 may be either positive or negative)
- Term 2 may be negative and Term 3 may be positive, thus tending to offset and cancel one another and reduce the magnitude of lifting or sinking (i.e., Term 1 may be either positive or negative)

Classical Omega Equation

- In this case, the dominant term will determine whether the atmosphere rises or sinks (i.e., stormy vs. clear skies).
- Because Terms 2 and 3 may oppose one another, each term's influence on vertical motion will be evaluated separately.

Evaluation of individual terms in the Omega Equation.

- Evaluation of Term 2 (Vorticity advection), **WITHOUT** considering Term 3 (temperature advection).
  - Positive Vorticity Advection:

$$VM = \frac{\left[\Delta(\zeta_g)_{by\ Advection}\right]}{\Delta z} + \ldots$$

(Term 1) (Term 2)

Terms in the Omega Equation

- **Positive Vorticity Advection**…

$$VM = \frac{\left[(\eta_g \text{Advection}_{500mb}) - (\eta_g \text{Advection}_{surface})\right]}{(Z_{500mb} - Z_{surface})} + \ldots$$

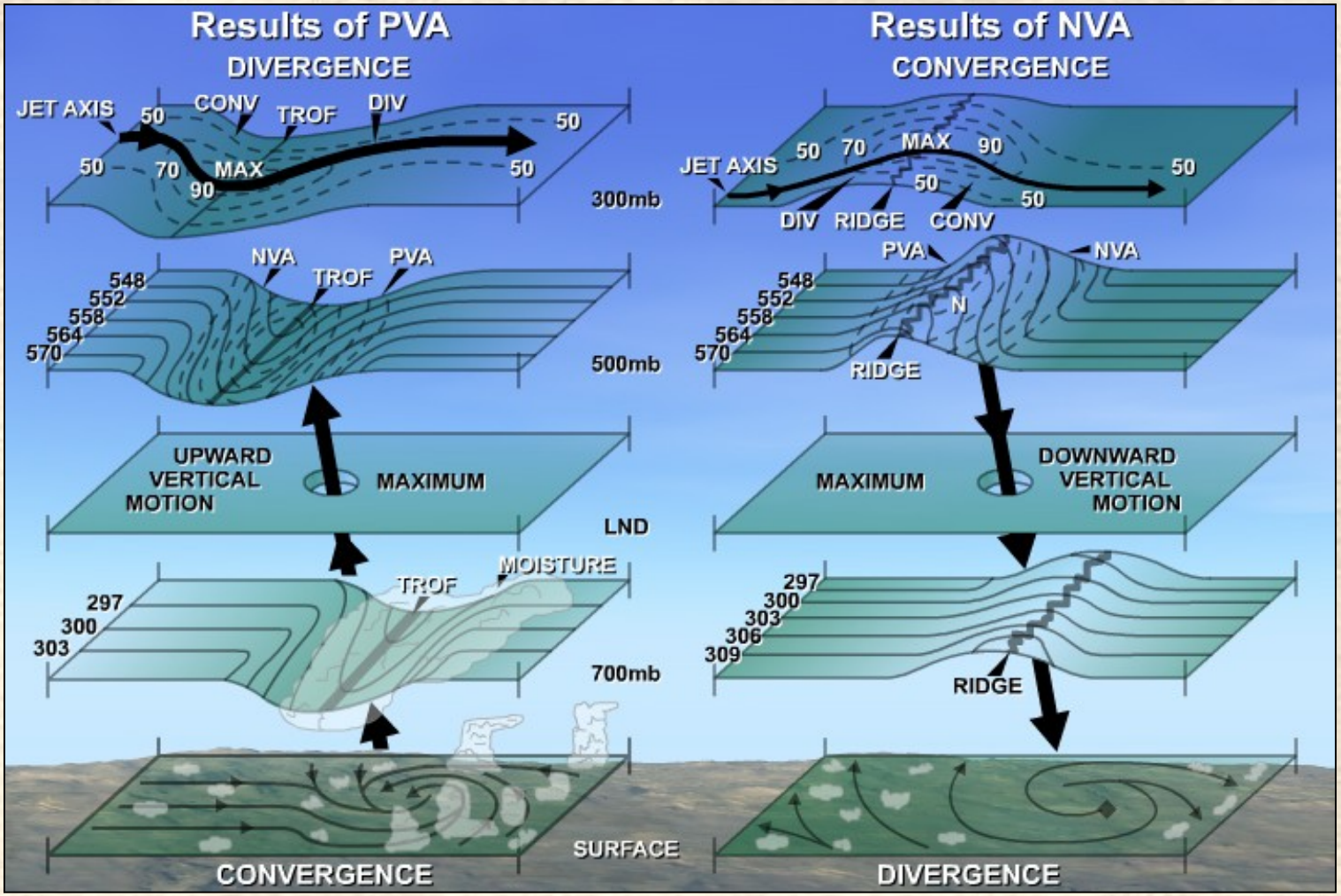
$$VM = \frac{\left[(\text{Large}+) - (\text{Small}+)\right]}{(\text{Large}0)} + \ldots = \frac{(+)}{(+)} = +$$

- **VM = Upward**

Terms in the Omega Equation

- PVA indicates
  - Areas where:
    - Divergence is occurring above the LND (i.e., level on non-divergence).
    - Convergence is occurring below the LND.
    - Upward vertical motion is occurring.
  - A lowering of isobaric heights, surface pressures, and possible cyclogenesis
  - Unstable weather conditions (e.g., clouds and/or precipitation)

Results of PVA



Terms in the Omega Equation

– Negative Vorticity Advection:

$$VM = \frac{\left[(\eta_g \text{Advection})_{500mb} - (\eta_g \text{Advection})_{surface}\right]}{(Z_{500mb} - Z_{surface})} + \ldots$$

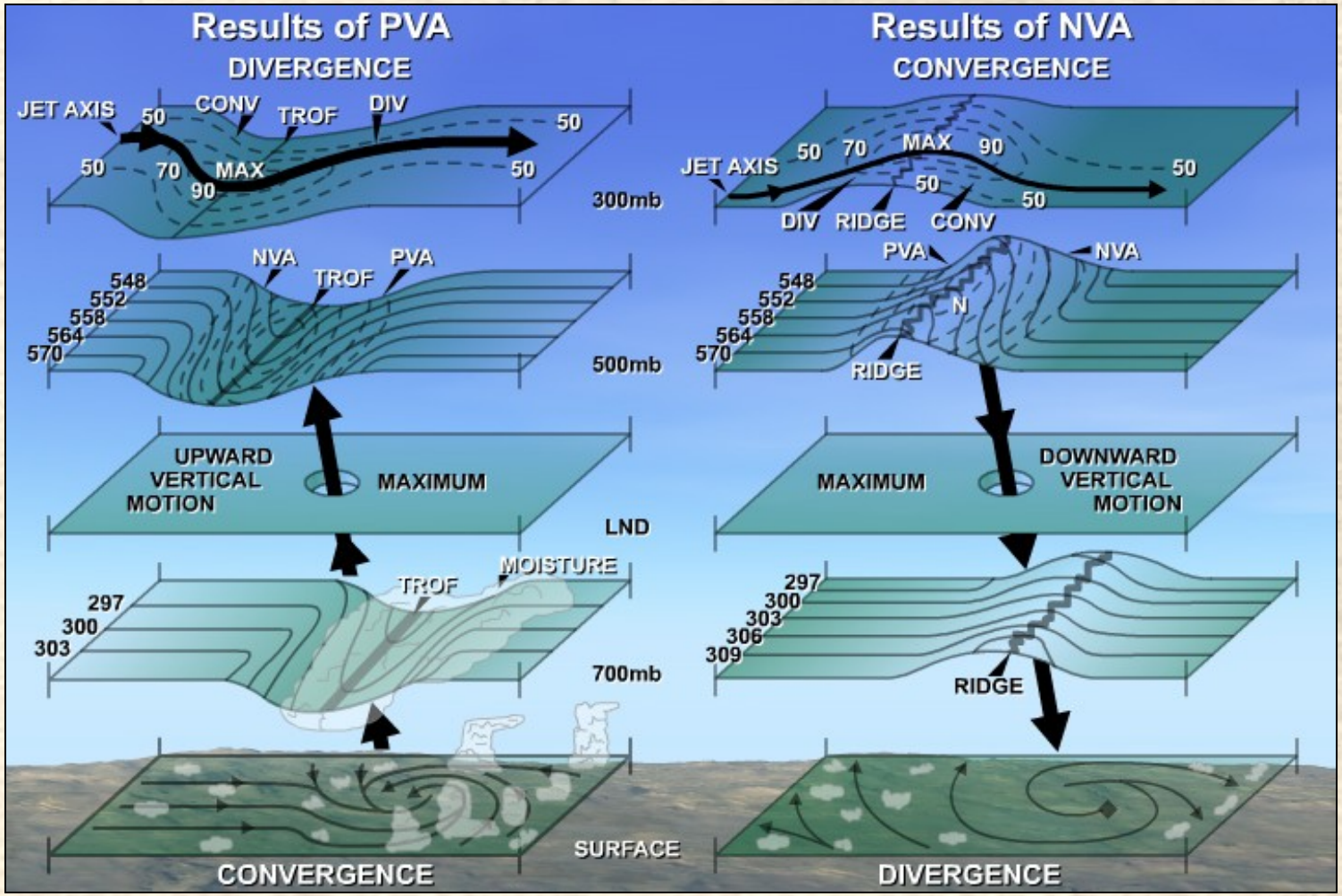
$$VM = \frac{\left[(\text{Large}) - (\text{Small})\right]}{(\text{Large} - 0)} + \ldots = \frac{(-)}{(+)} = -$$

– VM = Downward

Terms in the Omega Equation

- NVA indicates
  - Areas where:
    - Convergence is occurring above the LND.
    - Divergence is occurring below the LND.
    - Downward vertical motion is occurring.
  - An increase of isobaric heights, surface pressures, and possible anticyclogenesis
  - Stabilizing weather conditions (e.g., clear skies and dry conditions).

Results of NVA



Terms in the Omega Equation

- **Neutral vorticity advection**:

$$VM = \frac{\left[(\eta_g \text{Advection})_{500mb} - (\eta_g \text{Advection})_{surface}\right]}{(Z_{500mb} - Z_{surface})} + \ldots$$

$$VM = \frac{\left[(0) - (0)\right]}{(\text{Large}0)} + \ldots = \frac{(0)}{(+)} = 0$$

- VM = **Zero**

Terms in the Omega Equation

- Neutral vorticity advection indicates:
  - Areas where:
    - Vorticity and height isopleths are parallel.
    - Vorticity values have reached either a maximum or minimum value.
    - The wind flow is too light to advect the vorticity.
  - Little or NO convergence or divergence aloft is occurring.

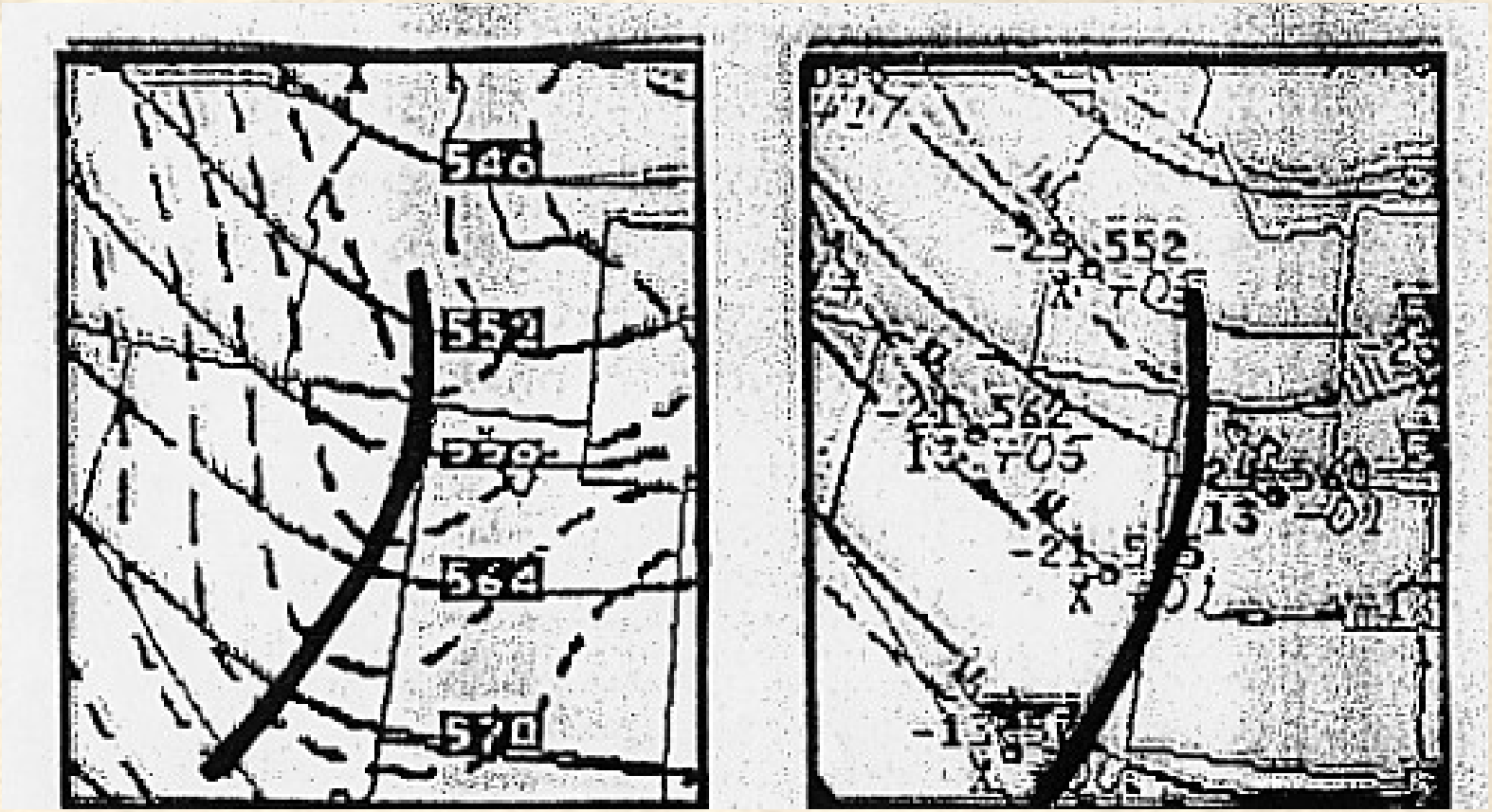
Terms in the Omega Equation

- Relationships between 500-mb height contours and vorticity isopleths.
  - Vorticity lobes are areas in which vorticity isopleths are elongated.

Terms in the Omega Equation

- Specific types of vorticity lobes
  - Advection lobes - lobes which are aligned perpendicular to the wind flow.
    - » These indicate the possible existence of a short wave trough or ridge at the 500 and/or 700-mb levels.

Advection vorticity lobes



Terms in the Omega Equation

- Shear lobes - lobes aligned more parallel to the wind flow - predominantly caused by speed shear.
  - Shear lobes are very useful in locating jet maxima.

Terms in the Omega Equation

- To evaluate the effect of temperature advection on vertical motion we may utilize one or more of the following:
  - the 1000-500-mb thickness analysis
  - the 1000-850 mb thickness analysis
  - the 925 mb analysis
  - the 850 mb analysis

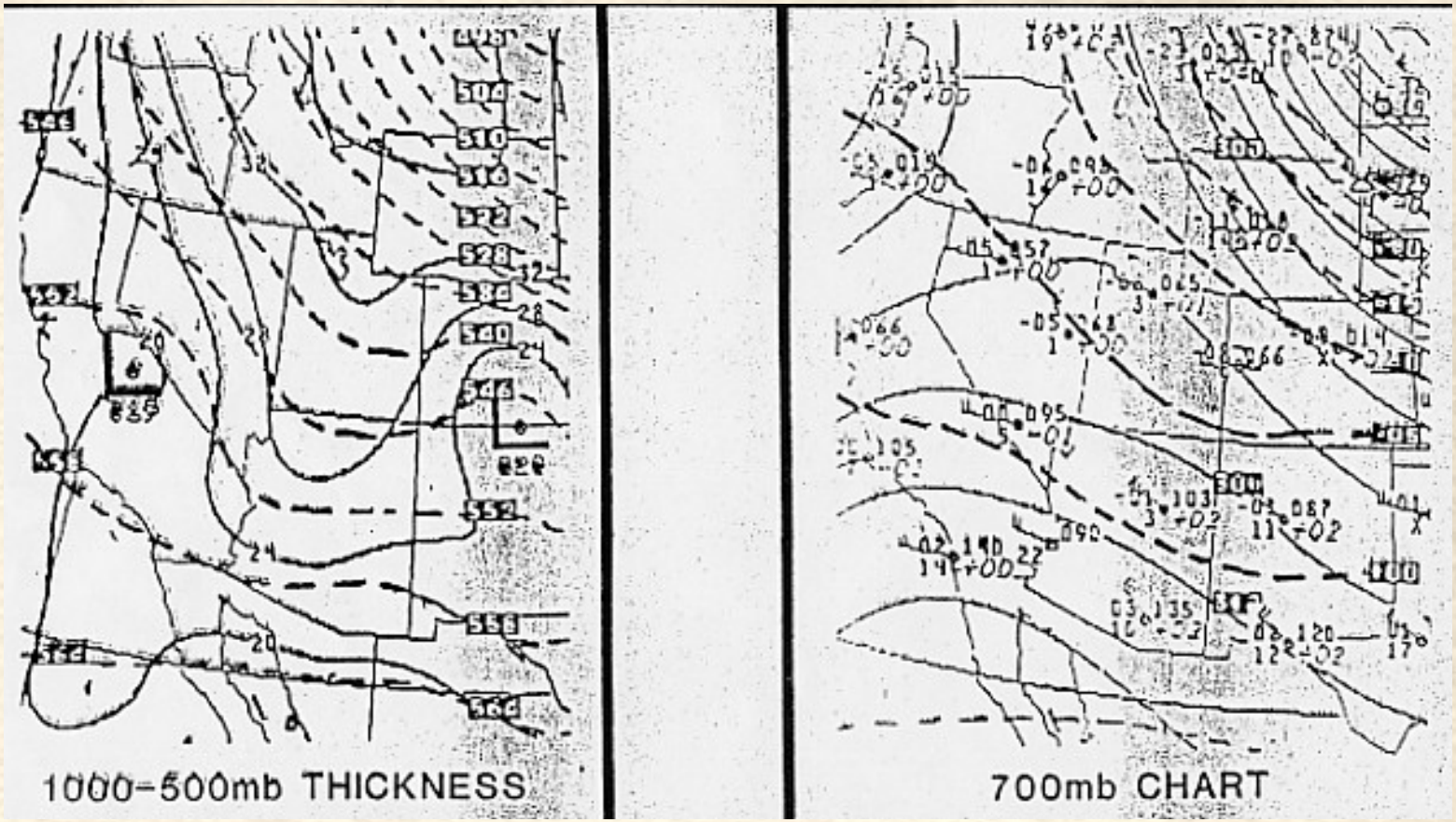
Terms in the Omega Equation

- The 1000/500-mb thickness chart provides an estimate of the lower tropospheric temperature advection. In some situations, strong outbreaks of polar or arctic air, the 1000/850-mb thickness chart would provide a better estimate.

Terms in the Omega Equation

- The 925 and 850-mb chart may be used in conjunction with the thickness chart in areas where the surface is near sea level.
- The 700-mb chart may be used as a back up for the thickness chart in mountainous areas.

Comparison of 700 mb chart to 1000-500-mb thickness chart over mountains



Terms in the Omega Equation

- Cold Air Advection (CAA) in the lower troposphere (i.e., near the gradient level):

Terms in the Omega Equation

- Evaluation of Term 3 (temperature advection at the gradient level) **WITHOUT** considering Term 2 (vorticity advection).

$$VM = \ldots + [TAdv] \quad (lower\ troposphere)$$

(Term 1) (Term 3)

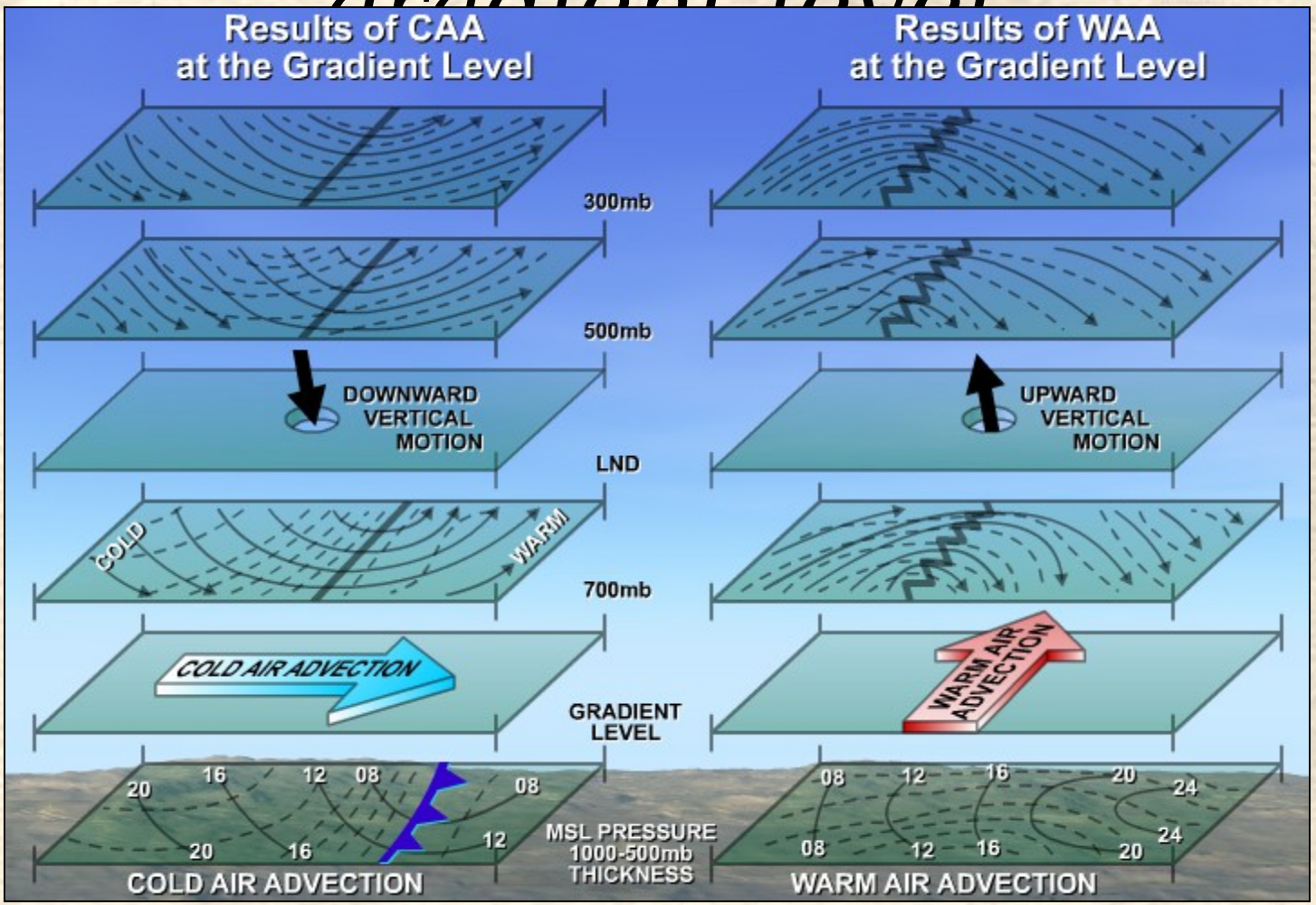
Terms in the Omega Equation

- **Cold Air Advection** …

$$VM = \ldots + \left[TAdv \right]_{(lower\ troposphere)}$$

- VM = … + [CAA]
- VM = … + [-]
- VM = **Downward**

Results of CAA at the gradient level



Terms in the Omega Equation

- Cold advection in the lower troposphere favors:
  - Downward Vertical Motion (subsidence).
  - Surface Pressure Rises (per pressure change equation; not discussed).

Terms in the Omega Equation

- **Warm Air Advection** (WAA) in the lower troposphere (i.e., near the gradient level):

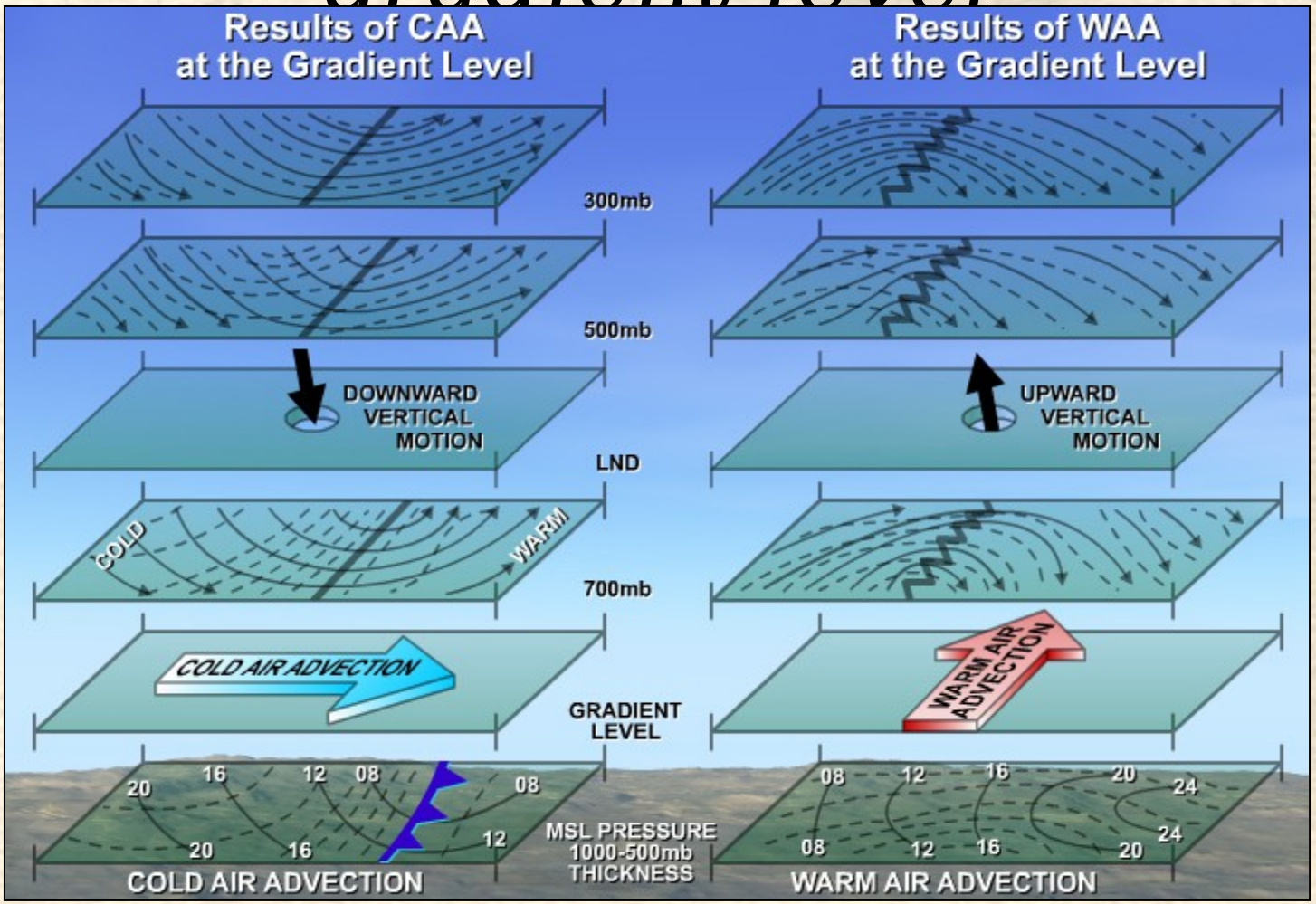
$$VM = \ldots + \left[TAdv_{(lower\ troposphere)}\right]$$

$$VM = \ldots + [WAA]$$

$$VM = \ldots + [\ +\ ]$$

- VM = **Upward**

Results of WAA at the gradient level



Terms in the Omega Equation

- Warm Air Advection
  - Upward vertical motion (ascent).
  - Surface pressure to fall (per pressure change equation; not discussed).

Terms in the Omega Equation

- Evaluation of Term 2 (vorticity advection) and Term 3 (temperature advection) combinations on Term 1 (vertical motion).
  - Advection patterns in Terms 2 and 3 will tend to reinforce or offset each other.

Possible temperature and vorticity advection combinations

Temperature Advection	Vorticity Advection			
		NEUTRAL	PVA	NVA
	NEUTRAL	0	UP	DOWN
	WAA	UP	UP	?
	CAA	DOWN	?	DOWN

Possible Temperature and Vorticity Advection Combin

Vort. Adv.	Temp. Adv.	Upper Heights	SFC Pres.	Vertical Motion	Stability	Clouds	Adiabatic Process
PVA		⇩	⇩	⇧	⇩	⇧	**Cooling**
NVA		⇧	⇧	⇩	⇧	⇩	**Warming**
Ø		No Change →					
	CAA	⇩	⇧	⇩	⇧	⇩	**Warming**
	WAA	⇧	⇩	⇧	⇩	⇧	**Cooling**
	Ø	No Change →					
PVA	CAA	⇩	?	?	?	?	?
PVA	WAA	?	⇩	⇧	⇩	⇧	**Cooling**
NVA	CAA	?	⇧	⇩	⇧	⇩	**Warming**
NVA	WAA	⇧	?	?	?	?	?

Terms in the Omega Equation

- **PVA and WAA**

$$VM = \frac{\left[(\eta_g \text{Advection})_{500mb} - (\eta_g \text{Advection})_{surface}\right]}{(Z_{500mb} - Z_{surface})} + \left[T\text{Adv}\right]_{(lower\ trop)}$$

$$VM = \frac{\left[(\text{Large}) - (\text{Small})\right]}{(\text{Large})} + [\text{WAA}] = \frac{(+)}{(+)} + [+] = +$$

- VM = up + up = **up**

Terms in the Omega Equation

– **NVA and WAA**

$$VM = \frac{\left[(\eta_g \text{Advection})_{500mb} - (\eta_g \text{Advection})_{surface}\right]}{(Z_{500mb} - Z_{surface})} + \left[\text{TAdv}\right]_{(lowetrop)}$$

$$VM = \frac{\left[(\text{Large}) - (\text{Small})\right]}{(\text{Large}0)} + [\text{WAA}] = \frac{(-)}{(+)} + [+] = ?$$

– VM = [-] + [+] = down + up = **?**

Terms in the Omega Equation

– PVA and CAA

$$VM = \frac{\left[(\eta_g \text{Advection})_{500mb} - (\eta_g \text{Advection})_{surface}\right]}{(Z_{500mb} - Z_{surface})} + \left[TAdv\right]_{(lower\ trop)}$$

$$VM = \frac{\left[(\text{Large}+) - (\text{Small}+)\right]}{(\text{Large}0)} + [CAA] = \frac{(+)}{(+)} + [-] = ?$$

– VM = [+] + [-] = up + down = **?**

Terms in the Omega Equation

- **NVA and CAA**

$$VM = \frac{\left[(\eta_g \text{Advection})_{500mb} - (\eta_g \text{Advection})_{surface}\right]}{(Z_{500mb} - Z_{surface})} + \left[\text{TAdv}\right]_{(lowertrop)}$$

$$VM = \frac{\left[(\text{Large}) - (\text{Small})\right]}{(\text{Large0})} + [\text{CAA}] \quad = \frac{(-)}{(+)} + [-] = -$$

- VM = [-] + [-] = down + down = **down**

Terms in the Omega Equation

- Vorticity and temperature advection are two important drivers of vertical motion on the synoptic scale, but as just shown, opposition of these two terms can lead to confusion and forecaster indecision because the dominant term (Term 2 or 3) actually driving the vertical motion may not be known. Thus, quantitatively combining these two terms into a single vertical motion indicator would be extremely helpful…

Terms in the Omega Equation

- Fortunately, there are two methods that do just that: 1) The Trenberth Form of the Omega Equation (Trenberth, 1978), and 2) the Q-Vector method.

Trenberth Form of the Omega Equation

- An alternate form of the Omega Equation, the Trenberth form, can be used as a second alternative to the Classical Q-G Omega Equation described below.
- Trenberth showed that for synoptic scale weather patterns:
  - Vertical motion is more sensitive to the advection of relative vorticity (ζ) than the advection of absolute vorticity ($\eta = \zeta + f$), thus simplifying Term 2.

Trenberth Form of the Omega Equation

- The effect of thermal advection on vertical motion could be captured better by the veering or backing of the geostrophic wind with height rather than the actual advection of isotherms or thickness by the geostrophic wind in the lower troposphere (thus dramatically altering Term 3).
- Also, vertical motion was more sensitive to vorticity advection by the thermal wind (V_T), rather than the geostrophic wind (V_g), thus further altering Term 2.

Trenberth Form of the Omega Equation

- Thus, Trenberth showed that Terms 2 and 3 in the classical Omega Equation could be combined into a single term, thus eliminating the often confusing cancellation of vorticity advection and temperature advection in terms 2 and 3 of the classical Omega Equation.

Trenberth Form of the Omega Equation

- The Trenberth form of the Omega Equation:

VM = (ζ Advection by V_T)

Trenberth Form of the Omega Equation

- Since V_T at 500 mb is parallel to the 1000-500 mb thickness contours, with lower thickness to the left of V_T (i.e. in the $+\Delta n$ direction).

Trenberth Form of the Omega Equation

- Interpretation: QG Vertical Motion may be visually estimated by the intersection of the 1000-500 mb thickness contours with 500 mb *relative* vorticity contours.
  - Ascent occurs when V_T blows across contours of higher ζ toward contours of lower ζ.

VM = (ζ Advection by V_T) = PVA = +

Trenberth Form of the Omega Equation

- Descent occurs when V_T blows across contours of lower ζ toward contours of higher ζ.

VM = (ζ Advection by V_T) = NVA

= -

Q-Vectors

- Q-Vectors provide an alternative way of using Q-G theory to imply regions of vertical motion.

Q-Vectors

- The Q-Vector is derived on an isobaric surface from
  - The magnitude of the horizontal temperature gradient, and
  - The vector manipulation of the horizontal shear of the geostrophic wind.

Q-Vectors

- Q-vectors may be calculated at several different isobaric levels (such as 850 mb, 500 mb and 300 mb).

Q-Vectors

- Q-vector interpretation
  - Convergence of Q-vectors represents upward vertical motion (lifting).
  - Divergence of Q-vectors represents downward vertical motion (subsidence).

Q-Vectors

- Omega Equation: Vertical Motion = PVA lifting + CAA sinking = ?
- 700 mb Q-Vector pattern: Vertical Motion = Q-vector convergence = lifting
- Result: PVA lifting dominates over CAA sinking.
  - or
- 700 mb Q-Vector pattern: Vertical Motion = Q-vector divergence = sinking
- Result: CAA sinking dominates over PVA lifting.

Q-Vectors

- Omega Equation: Vertical Motion = NVA sinking + WAA lifting = ?
  - 700 mb Q-Vector pattern: Vertical Motion = Q-vector divergence = sinking
  - Result: NVA sinking dominates over WAA lifting.
    - or
  - 700 mb Q-Vector pattern: Vertical Motion = Q-vector convergence = lifting
  - Result: WAA lifting dominates over NVA sinking.

Isentropic Analysis of Vertical Motion:

- On the synoptic scale, unsaturated air moves dry adiabatically. Along dry adiabats (i.e., isentropes), potential temperature is conserved (i.e., remains unchanged). Therefore, air follows isentropic (i.e., potential temperature) surfaces much better than it follows isobaric (i.e., pressure) surfaces.

Isentropic Analysis of Vertical Motion:

- There are two types of isentropic products which are great aids to forecasters:
  - Isentropic charts
    - Similar to isobaric charts (i.e., 850 or 500 mb charts, etc…), except potential temperature (i.e., 290 K or 300K, etc…) is constant instead of pressure.
  - Isentropic cross sections
    - Similar to vertical cross sections, except isobars are replaced by isentropes.

Isentropic Analysis of Vertical Motion:

- Isentropes are lines of constant potential temperature. Potential temperature is represented by the Greek symbol θ (pronounced “theta”).

Isentropic Analysis of Vertical Motion:

- Advantages: There are many advantages to looking at the upper atmosphere from an isentropic perspective. Isentropic products are superior to isobaric products in the depiction of:

Isentropic Analysis of Vertical Motion:

– Vertical motion

- From an isentropic perspective, vertical motion (VM) is the result of 3 processes:

VM = local pressure tendency + pressure advection + diabatic processes

(1) (2) (3)

Isentropic Analysis of Vertical Motion:

VM = local pressure tendency + pressure advection + diabatic processes

(1) (2) (3)

Where:

- Term 1 = the local change in pressure on an isobaric surface due to the movement or intensity change of high and low pressure systems.
- Term 2 = the advection of isobars by wind flow directed across the isobars
- Term 3 = diabatic process, such as temperature changes due to latent heating (e.g., convection), solar heating, evaporative cooling, radiational cooling, etc…

Isentropic Analysis of Vertical Motion:

- Vertical motion is the most important advantage of isentropic analysis.
- By applying a few assumptions to the above equation, Term 2 (pressure advection) becomes the most important indicator of vertical motion.

  Assumptions:

  – The high and low pressure systems are slow-moving and not rapidly changing intensity.

    » Time-dependent pressure changes in Term 1 becomes small or is eliminated.

Isentropic Analysis of Vertical Motion:

Assumptions:

- The winds on the isentropic surface are adjusted relative to the moving high and low pressure systems.
  - » By allowing the computer to subtract the motion of the pressure system from the actual wind motion on an isentropic surface, Term 1's influence is eliminated even for fast moving pressure systems (assuming these systems are not undergoing rapid intensity changes).

Isentropic Analysis of Vertical Motion:

Assumptions:

- Precipitation influences are ignored
  - » Latent heating and evaporational cooling influences in Term 3 are eliminated.

- The isentropic surface is above the planetary boundary layer (i.e., the isentropic surface is aloft and not near the ground).
  - » Solar heating and radiational cooling of air near the ground (Term 3) is eliminated.

Isentropic Analysis of Vertical Motion:

- If all the assumptions are met, Term 2 (pressure advection) represents the dominant indicator of isentropic vertical motion.
  - The Isentropic (θ) surfaces vary in elevation from one place to another, and may take on a wavy appearance on cross sections.
  - In general, these θ surfaces are found at
    - » higher levels over colder air masses or higher pressure, and
    - » lower levels over warmer air masses or lower pressure

Isentropic Analysis of Vertical Motion:

- Air parcels will remain on the wavy θ surface rising up θ "ridges" and dropping into θ "troughs". This is best seen on an isentropic cross section. Thus if isentropes slope upward along the path of the wind there will generally be upward motion as the air parcel climbs the "hill" and vice-versa. This has great forecast implications since rising air, or lift, generally produces clouds/precipitation and sinking air generally produces clear skies and dry conditions. Thus forecasters can look at computer analyses and forecasts of various isentropic surfaces to actually see how much lift (or descent) is or will occur at given points in time (examples are provided later in this section).

Isentropic Analysis of Vertical Motion:

- Moisture advection (indicated by mixing ratio or specific humidity).
  - Moisture advects along isentropes.
  - Isolated dry or moist “pockets” of moisture often observed on isobaric charts are eliminated.
  - Better depiction of atmospheric conveyor belts associated with mid-latitude cyclones.

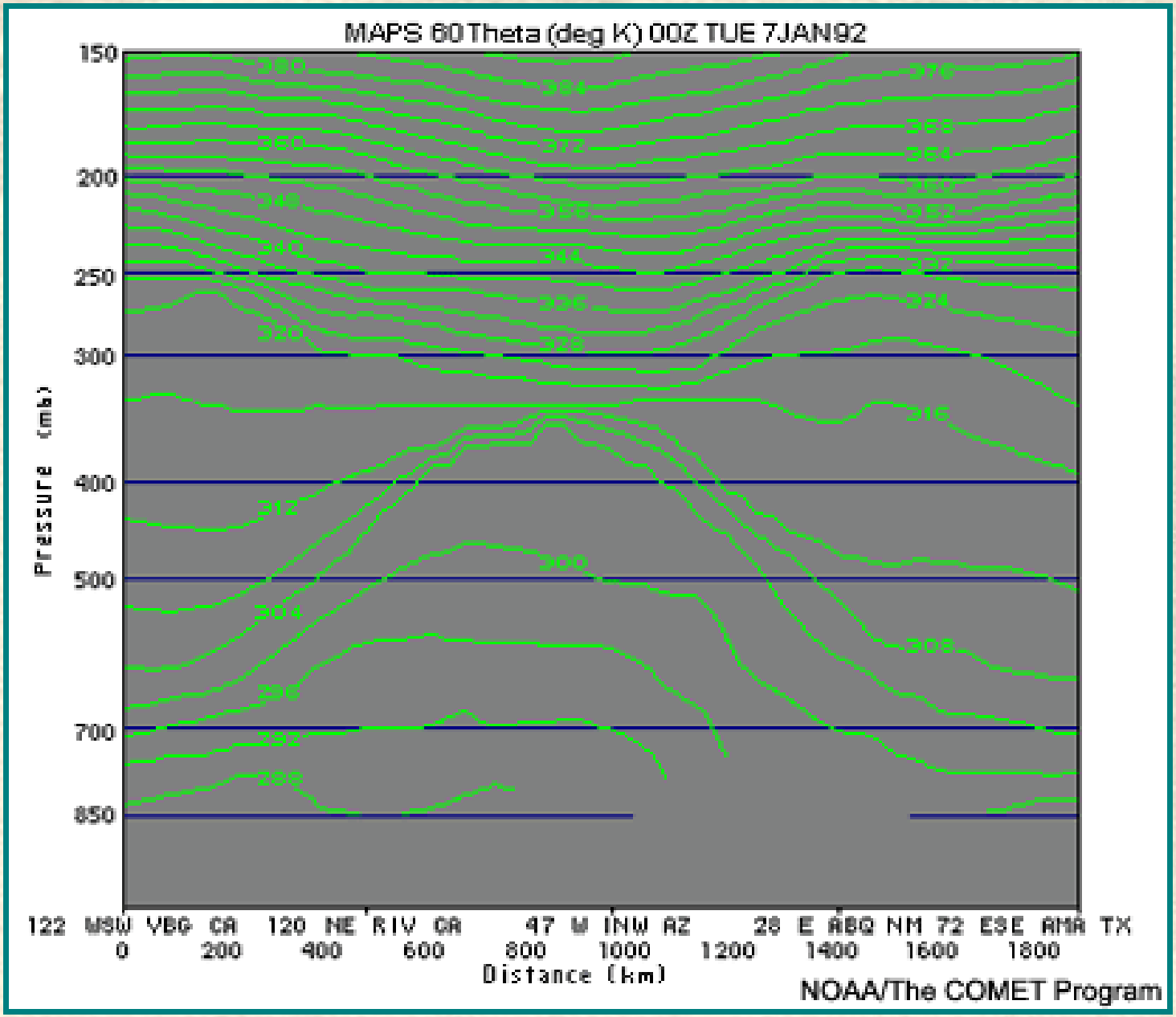
Isentropic Analysis of Vertical Motion:

- Moisture convergence/divergence

- Temperature advection
  - Isotherms parallel isobars on isentropic surfaces, so wind directed across the isobars indicates temperature advection.

Isentropic Analysis of Vertical Motion:

- Static stability, upper-level fronts, tropopauses, tropopause folds, and thermal support for jet streams on cross sections.
  - Stability varies depending on the vertical spacing of isentropes.
    - » Widely spaced isentropes indicate more neutral stability conditions (i.e., closer to dry adiabatic)
    - » Tightly packed isentropes indicate extremely stable conditions (i.e., temperature inversions).


MAPS 60 Theta (deg K) 00Z TUE 7JAN92
Pressure (mb)
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122 MSW VBG CA 120 NE RIV CA 47 W INW AZ 28 E ABQ NM 72 ESE AMA TX
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Distance (km)
NOAA/The COMET Program

Isentropic Analysis of Vertical Motion:

- Frontal positions above the surface are often depicted as sloped regions of tightly-spaced isentropes.

- The tropopause is often depicted at the bottom of an extensive region of tightly-packed isentropes generally above 400 mb

Isentropic Analysis of Vertical Motion:

- Sharp downward dips in the tropopause often indicate regions of tropopause folding.

- Jet stream positions are often on the equatorward side of tropopause folds and often reside above lower-tropospheric frontal zones.

Isentropic Analysis of Vertical Motion:

- Disadvantages: Isentropic charts are inferior to isobaric charts because:
  - *Manual* construction of isentropic charts is more difficult than isobaric charts.
  - Isentropic charts in the lower troposphere tend to intersect the ground more frequently than isobaric charts.

Isentropic Analysis of Vertical Motion:

- Selecting the correct potential temperature (i.e., isentrope) is more difficult than selecting the correct pressure level. Selection of the precise isentrope (for instance, 290 K vs. 310 K) varies with the weather pattern. Two methods of isentrope selection work best:

Isentropic Analysis of Vertical Motion:

- For lower-tropospheric details, Djuric (1994) suggests using the theta surface corresponding to the warmest temperature in the warm sector of a mid-latitude cyclone.
  - Example: Assume 30˚C is the warmest temperature in the warm sector. Convert this temperature from ˚C to K (Formula: K = 273 + ˚C) and select this K value as the isentropic surface.

Isentropic Analysis of Vertical Motion:

- Generate an isentropic cross section through the weather system of interest, then select an isentrope appropriate to the weather feature of interest. Use this isentrope value to create an isentropic chart.

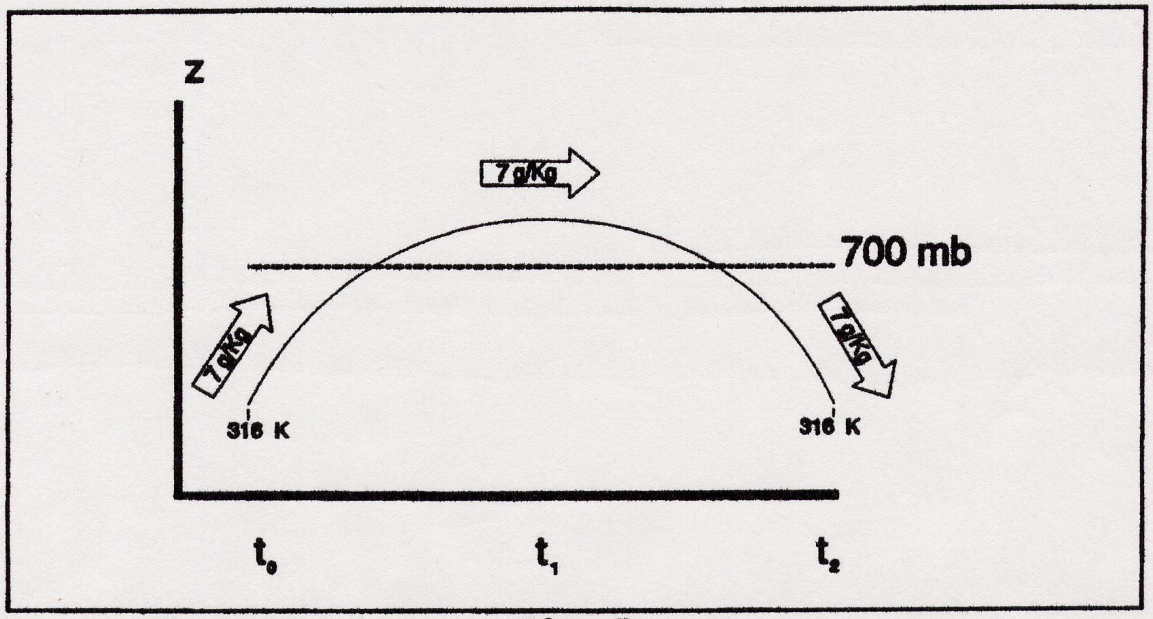


Fig. 5

Western Region Technical Attachment
No. 93-14
May 18, 1993

A REVIEW OF ISENTROPIC ANALYSIS WITH APPLICATIONS TO PCGRIDS

David Pike - WSFO Salt Lake City

Isentropic Analysis of Vertical Motion:

- Isentropic charts generally contain:
  - Isobars or isotherms (they always parallel one another and thus one can substitute for the other).
  - Moisture (relative humidity, specific humidity, or mixing ratio).
  - Plotted winds or streamlines ***

Isentropic Analysis of Vertical Motion:

- **If precipitation is present, the latent heating due to condensation warms the air (activating Term 3) and forces air parcels to “jump” to higher isentropic surfaces. Thus, the air parcel is no longer following the original isentropic surface. If this assumption is violated, lifting may still be detected on the isentropic chart by cross-isobar flow of the wind.**

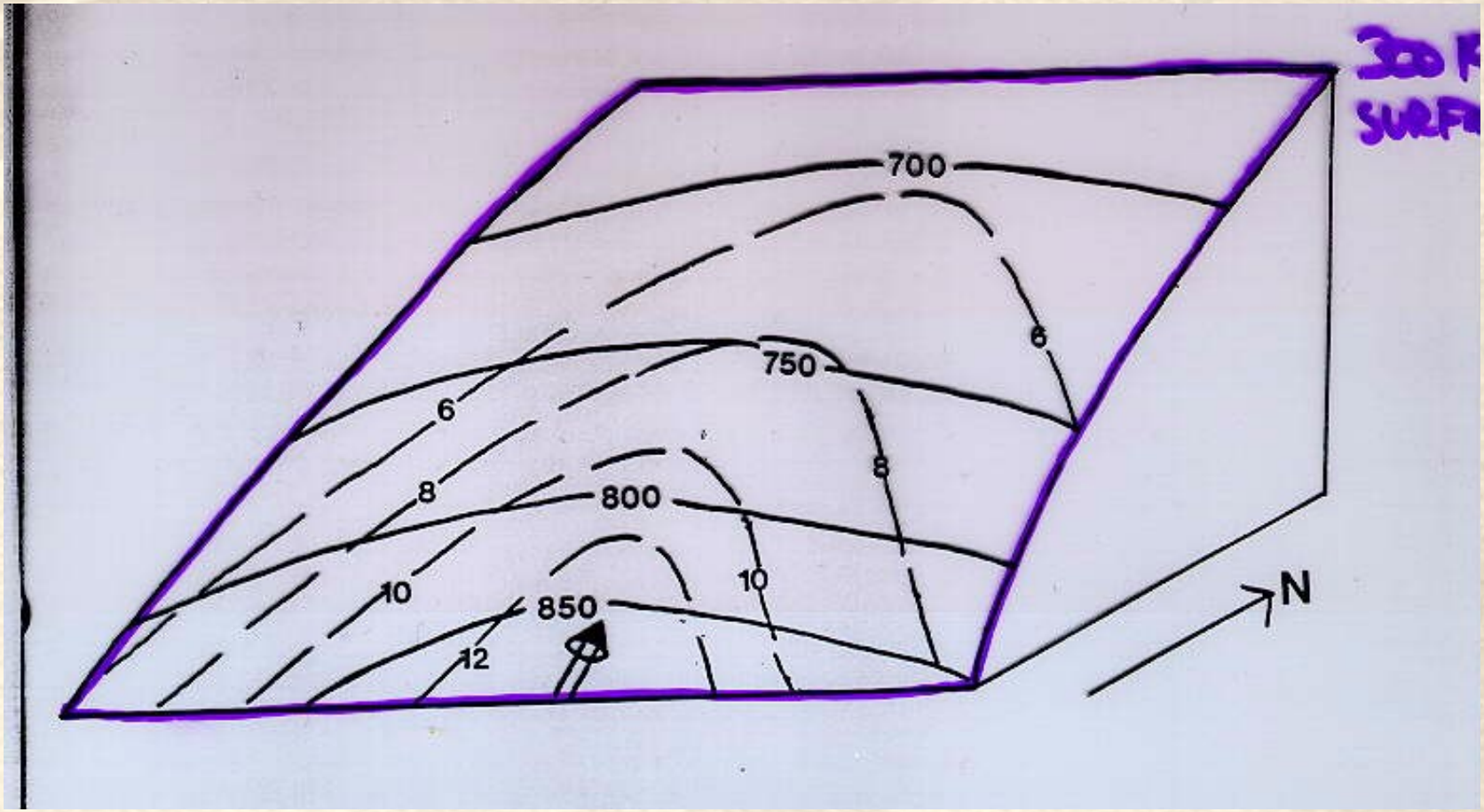


Figure from the National Weather Service Forecast Office in Fargo, South Dakota at http://www.crh.noaa.gov/fsd/upper.htm)

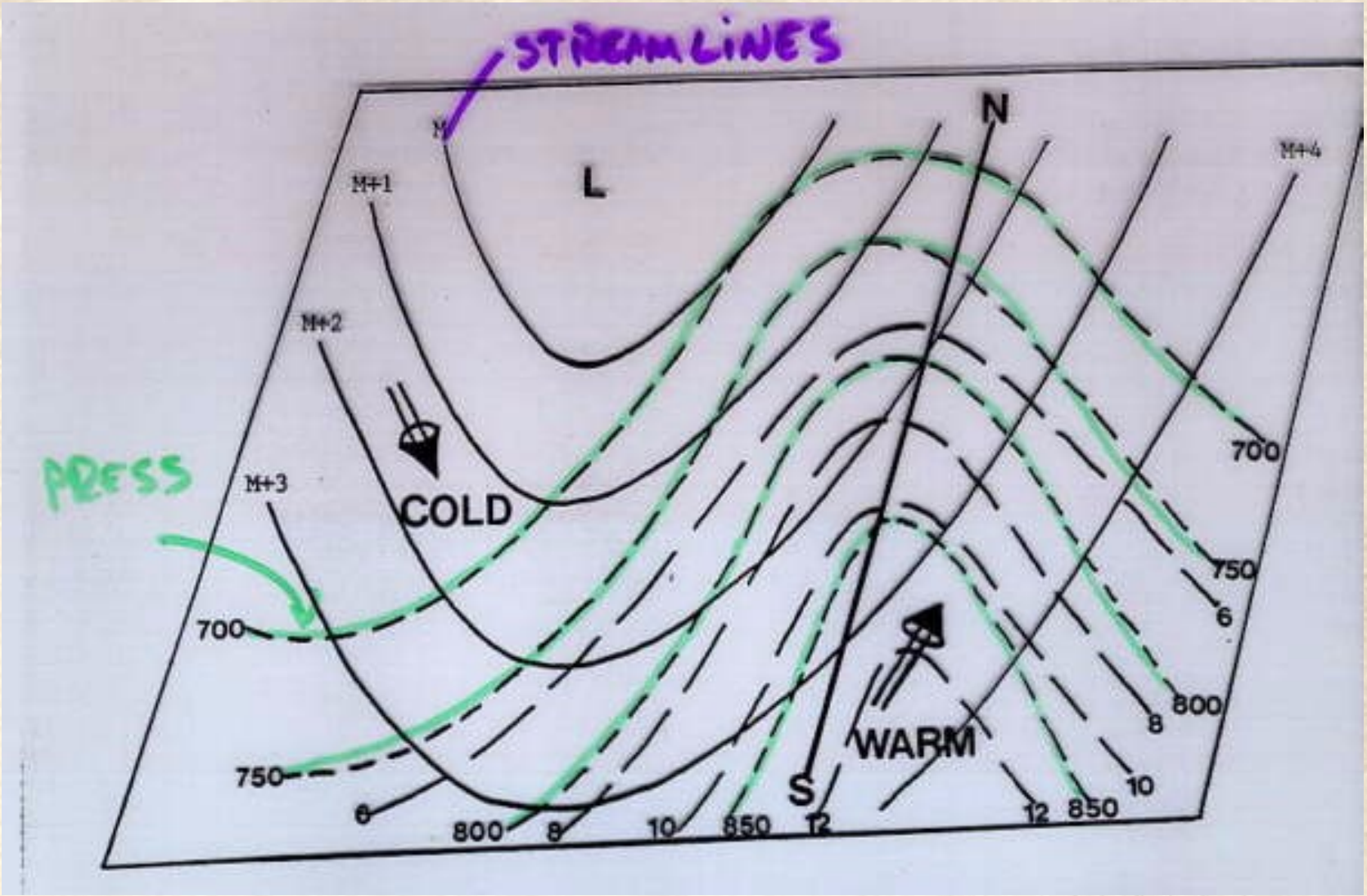


Figure from the National Weather Service Forecast Office in Fargo, South Dakota at http://www.crh.noaa.gov/fsd/upper.htm)

Re **93-**

Western Region Technical Attachment
No. 93-14
May 18, 1993

A REVIEW OF ISENTROPIC ANALYSIS WITH APPLICATIONS TO PCGRIDS

David Pike - WSFO Salt Lake City

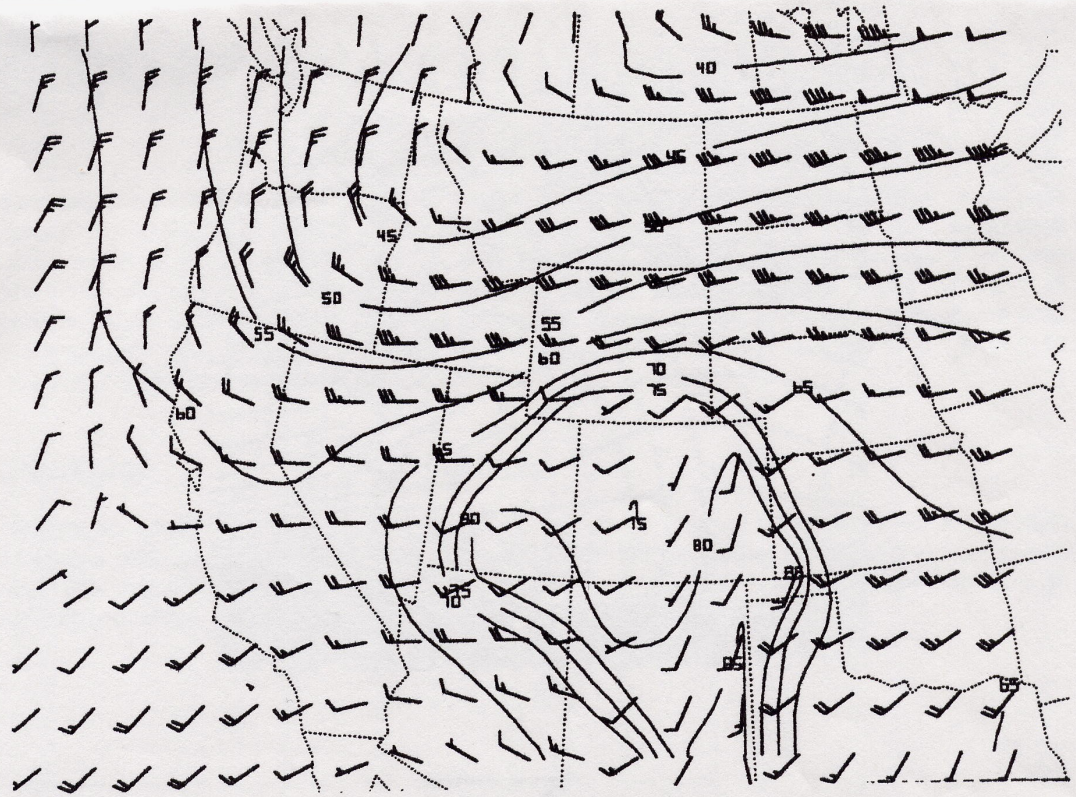
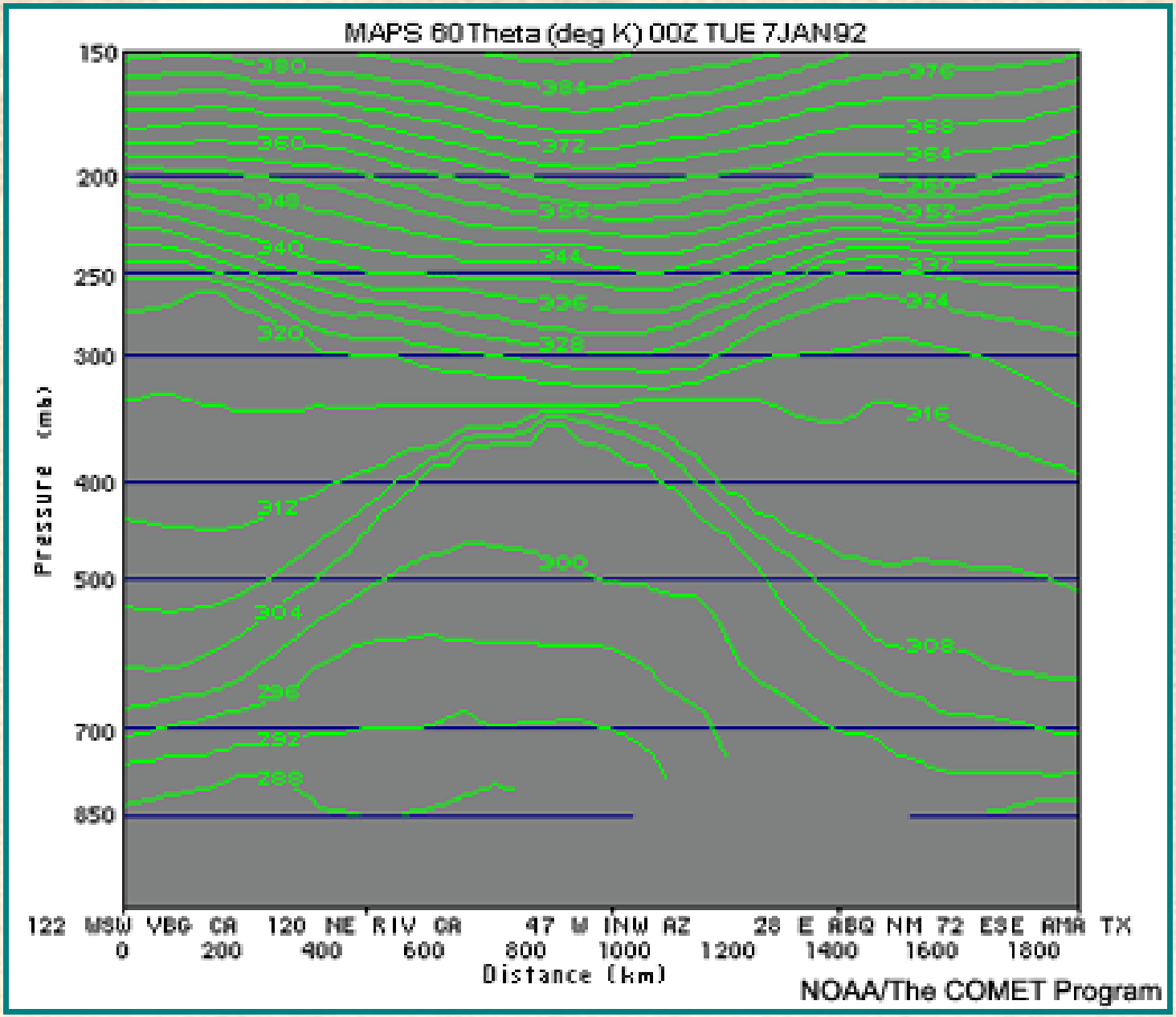


Fig. 2 316K isentropic surface with pressure (x10 mb) and wind (knots).


MAPS 60 Theta (deg K) 00Z TUE 7JAN92
Pressure (mb)
150
200
250
300
400
500
700
850
360
352
344
336
328
320
312
304
296
288
280
376
368
360
352
344
336
328
320
312
304
296
288
280
122 MSW VBG CA 120 NE RIV CA 47 W INW AZ 28 E ABQ NM 72 ESE AMA TX
0 200 400 600 800 1000 1200 1400 1600 1800
Distance (km)
NOAA/The COMET Program

- APPLICATION ST: Review Exercise 9
- EVALUATION: Informal Appraisal
  Formal Written Test

References

- References:
  - AC006A Aviation Weather for Pilots and Flight Operations Personnel, FAA & NOAA
  - AFGWC WFOI 105-1 15 June 87, Principles and Philosophy of Analysis and Prognosis
  - AFM 51 -12 Weather for Aircrews
  - AMS, 1959; Glossary of Meteorology

References

- AWS/TR-212 Application of Meteorological Satellite Data in Analysis and Forecasting
- AWS/TN-79/3 Satellite Applications Information Notes, October 1975 - December 1978
- AWS/TR-79/3 Weldon, R; Satellite Training Course Notes, Part IV - Cloud patterns and the upper air wind field
- AWS/TN-83/1 Doswell, CA; The Operational Meteorology of Convective Weather Vol. 1: Operational Mesoanalysis

References

- AWSP 52-1 Forecaster Preparatory Program
- AWSP 105-56 Meteorological Techniques (ch.2, Winds)
- Ahrens, C. D., 2000: Meteorology Today, 6th Ed., Brooks/Cole, Pacific Gove, CA, 528 pp.
- Djuric, D., 1994: Weather Analysis, Prentice Hall, Englewood Cliffs, NJ, 304 pp.
- Dutton, JA, 1986 The Ceaseless Wind, An Introduction to the Theory of Atmospheric Motion. Dover Publications, Inc., 617 pp.

References

- ECI Course 2570 Weather Technician Crs
- Haltiner, GJ and FL Martin, 1957 Dynamical and Physical Meteorology. McGraw-Hill, New York, NY, 470 pp.
- Hidy, SM, 1967 The Winds, The Origins and Behavior of Atmospheric Motion. D.Van Nostrand Co., Inc., 174 pp.
- Holton, JR, 1992: Introduction to Dynamic Meteorology. 3rd Ed., Academic Press, New York, NY, 511 pp.

References

- NAVEDTRA 10362-B, 1974 Aerographers Mate 1 & C
- NAVEDTRA 10363-E, 1976 Aerographers Mate 3 & 2
- NAVEDTRA 40502 Forecasting for the Mid-latitudes
- Palm'en, E and CW Newton 1969; Atmospheric Circulation Systems, Their Structure and Physical Interpretation. Academic Press, New York, NY, 603 pp .

References

- Reiter, ER, 1963 Jet Stream Meteorology
- NOAA Weather Service Forecasters Handbook #6, 1985; Satellite Imagery Interpretation for Forecasters
- 3WW/TN-81/1 Satellite Interpretation
- Trenberth, K. E., 1978: On the interpretation of the diagnostic quasi-geostrophic omega equation. *Mon. Wea. Rev.*, 106, 131-137.